METHOD TO EVALUATE MICROCOMPUTERS FOR
NON-TACTICAL SHIPBOARD USE

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THESIS

METHOD TO EVALUATE MICROCOMPUTERS FOR
NON-TACTICAL SHIPBOARD USE

by

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by

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis outlines an approach to determine what microcomputer hardware, acceptable for various administrative applications on small U. S. Navy ships, can be purchased "off the shelf" from commercial sources. It provides a cost and functional analysis of various computer systems and provides information concerning software support for these systems. An analysis of various potential applications specifies administrative functions that are recommended for automation. It also specifies other administrative functions that are not recommended for automation, with reasons why they should not be automated.

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I. INTRODUCTION

The March 1979 Quarterly Report for the Chemical Fund Inc. states that:

> "Many analysts foresee a proliferation of intelligent electronics so widespread over the next ten years that the 1980's may be known as the 'Microcomputer Decade'."

It is estimated that annual demand for microcomputers may reach 300 million units by 1984, and triple that number may be in use by the end of the decade. Nearly two-thirds of these applications will be in previously non-electronic data processing markets and will dramatically increase the efficiency and output of mechanical devices, such as office equipment and word processing systems.

Vice Admiral William R. St George, Commander Naval Surface Force Pacific, in a presentation at the Naval Postgraduate School in the spring of 1979, predicted that, in the late 1980's, one out of every two eligible males, would have to be recruited to maintain an all volunteer force. This has not been set as a recruiting goal, as it would be unrealistic, especially if predicated on the difficulty encountered in meeting present goals. The comment

was delivered to demonstrate how the reduction of available males who will be of recruitable age at the end of the decade will affect the future of the U.S. Navy. This reduction of available resources is primarily due to the decreasing birth rate now prevalent in the United States. Even though women are now being accepted in sea-going jobs, most small combatants of the 1980's probably will not be capable of accomodating sexually integrated crews, even if the U.S. Congress passed legislation allowing women to go into combat.

This prediction of decreasing available manpower is being taken seriously by the U.S. Navy, as the new class of Guided Missile Frigates (FFG) is being built with a "reduced manning" concept in mind. This concept has very little leeway for accomplishing anything but functions that are essential to the ship's operations. In fact, much of the equipment installed on the ships will be repaired by outside activities. This indicates how little time there is for correcting administrative errors such as retyping fitness reports, reformatting status reports, or rewriting quarterly reports.

Most shipboard information handling operations are presently performed manually. This is time consuming. It is slow due to the numerous corrections and rewrites that must be made to most documents that are processed by hand. If

personnel readiness and operational readiness are to be maintained effectively during this period of declining available resources, a more efficient and effective means of information handling must be employed.

The armed forces in general, and the U. S. Navy in particular, have long been pioneers in the development of new systems that have had industrial applications. Unfortunately, an automated information handling system has not been one of these. Large computer systems acquired by the armed services normally lag behind the state of the art due to the long procurement process inherent in complying with Public Law 89-306 [1], commonly referred to as the "Brook's Bill". Small computer systems are virtually non-existant on board small ships. This may be due to a lack of knowledge of the capablity of microcomputer systems. This lack of knowledge can be attributed to the rapid advancement of microcomputer technology, coupled with a reluctance to try something new.

The objective of this thesis is to outline an approach to determine what hardware that is acceptable for existing, and projected, administrative applications on small ships can now be purchased "off the shelf". "Small ships" describe all ships up to, and including, present day cruisers. This approach will also be valid for other small administrative units such as afloat staffs, aircraft squadrons, and small

bases. It will provide a cost analysis of specific microcomputer systems as well as provide information concerning essential software support for these systems. This information can be used to procure microcomputer systems to help alleviate the administrative burden presently placed on the officers and men of the fleet.

II. NATURE OF THE PROBLEM

A. BACKGROUND

Several efforts have been made to develop computer based shipboard information systems for the U. S. Navy. Until recently, however, they have all been implemented on large ships. Carriers, Repair Ships, and the large Auxilliaries have been successfully using a minicomputer, the AN/UYK-5(V), for administrative applications for a number of years. It has proved so successful that a follow on program, the "Shipboard Non-Tactical ADP Program" (SNAP I) is being implemented to upgrade ships that are currently using the AN/UYK-5(V).

1. USS Gridley Minicomputer System

In 1975 the Navy Personnel Research and Development Center (NPRDC) implemented a General Damage Control Personnel Qualification Standard (PQS-2) computerized training package on board USS Gridley (CG-21) using a Data General NOVA-1200 minicomputer system. Nineteen management applications in areas of personnel, training, administration, operations, material maintenence management, and supply were developed and implemented on Gridley. The

equipment and basic software for these programs were obtained from USS Dahlgren, following an unsuccessful attempt to automate PQS-2 on that ship. NPRDC determined that the main reason for the failure of the Dahlgren experiment was the lack of involvement of senior officers and non-computer oriented personnel. When the few officers and enlisted personnel who were conducting the trial were transferred the program was held back from a lack of knowledge. This resulted in a rapid decline of interest which eventually led to complete abandonment of the automation attempt. In addition to the hardware and software received from Dahlgren, these valuable lessons learned were also made available for the Gridley personnel, and steps were taken to avoid repeating them.

The program proved so successful on Gridley that, in 1978, the NOVA was replaced by a Navy Training System 11H69 (Digital Equipment Corperation's PDP 11/60) with personnel and training management support software. To assist in designing and installing a shipboard Learning Resource Center (LRC), NPRDC provided Gridley with Computer Managed Instruction (CMI) support software. The LRC consisted of three carrels with associated terminals. Training materials consisted of programs to provide self-training in General Damage Control PQS, Propulsion Engineering PQS, Material Management PQS and Shipboard Radioman Skills PQS. Computer games were also provided to maintain interest and train

personnel to use the system. High level languages that were implemented in the system included BASIC PLUS, FORTRAN IV, COBOL and PASCAL. The PASCAL was purchased from an outside contractor. MACRO, the PDP-11/60 assembly language, is also implemented [2].

Gridley is presently automating their supply system, consisting of 23,000 line items. It has been determined, as of July 1979, that a 3.4 megabyte data base will be required to support this effort. Coordinated Ship's Maintenance Project (CSMP) will also be automated this fiscal year on Gridley. This administrative tool can be used to indicate recurring problem areas in all major equipments on the ship and is also used to determine problems that may be common to similiar equipments installed on different ships. CSMP can also be used to determine what equipments require repair whenever the ship is in an overhaul status. It will require an additional one megabyte in the data base to accomplish this. Personnel Records are not yet being automated on Gridley's system.

2. Shipboard Non-Tactical Data Processing Program

Shipboard Non-Tactical Data Processing Program (SNAP II) is a program directed toward providing a non-tactical ADP capability in all surface ships and submarines that are not presently equipped. Implementation of SNAP II is desired

by the end of calender year 1980. Software support will be provided to fleet users by a central design and programming activity. The SNAP II system is designed to provide automation in three areas:

1. PAY and PERSONNEL
2. SUPPLY and FINANCIAL
3. MAINTENANCE

The overall plan for SNAP II is to procure twelve prototype systems for field evaluation. If they prove to be successful, and meet all specifications, an additional 438 systems will be installed on ships. This implementation will stretch over an eight year period.

SNAP II is designed to be compatable with the SNAP I project so that the output of either system can be used as an input to the other and common programs can be supplied for both systems.

There appear to be serious implementation problems with the SNAP II program, as presently envisioned, which are documented in a study conducted at the Naval Postgraduate School during the spring of 1979 [3]. These include an implied stringent security capability and the implementation and support schedule that will extend over a 16 year period.

B. SHIPBOARD APPLICATIONS

Many of the reports that originate from U. S. Navy ships are formatted. This is to provide direct entry into automatic processing equipment at the receiving end. These reports are prime candidates for shipboard automation as they are presently formatted by hand. Often the format for these reports is complex and difficult for humans to understand which results in wasted time correcting errors. Computerized formatting would eliminate these errors. Many other applications that are presently automated in the business world are being done manually on board ship and could be computerized with little effort.

Some of the candidates for automatic formatting deal with classified information. Due to the rapid increase in hobbyist use of microcomputers, many people are highly qualified in their use. To ensure that security is maintained it is necessary to assume that sailors on U. S. Navy ships are among these qualified people. This is beneficial, if the assumption is valid, as it reduces the time required to train users, but it is detrimental as it makes present micro (and mini) computer security methods questionable in their ability to withstand penetration attempts.

Schell discussed the vulnarability of computers to penetration in an article written for the Air University Review in 1979 [4]. Although this article was written about

large computers, and classified documents, it is just as appropriate for microcomputers and information that is subject to Public Law 93-597, the Privacy Act of 1974 [5].

The U. S. Air Force utilized a team of computer security experts (Tiger Team) that attempted to penetrate computer security. The team normally had little difficulty accomplishing its objective. Granted, the members of the team were more sophisticated than the shipboard user, but their objective was also of a proportionately higher level of sophistication, and shipboard users have more chances to attempt the penetration.

Many of the early applications of the shipboard computer system are likely to be of the text formatted type. This is not only worthwhile in reducing the time required to completly re-type documents that have been revised, but also in training personnel in the use of the system.

There are other applications that can, and should, be implemented immediately. PQS is a prime candidate for early implementation, as well as many supply and other training functions. The remainder of this chapter will expound, by department, on these applications.

1. Operations Department

A ship's Operation Department requires the majority of its reports and messages to be formatted. This is presently being done manually. One of these reports, the Naval Force Status Report (NAVFORSTAT), was developed as an interactive program for a portion of a thesis concerning Report Originating Systems (ROS) [6]. This approach could also be used by a centralized activity to develop computer assisted formating of Casualty Reports (CASREPTS), Movement Reports (MOVREPS), Weather Synopsis and short fuzed emergency reports, such as Navy Blue and Bent Spear.

Training could be utilized for each of the ratings within the Operations Department by utilizing a computerized assisted instruction technique for PQS. The diskettes, with the PQS package required, should be physically write protected so no information that might be altered in the TPA could inadvertantly be transferred to it.

2. Engineering Department

In addition to the training described under the Operations Department, which is apropos for all departments on the ship, the Engineering Department could utilize an interactive approach to providing work requests for any of the various types of overhaul periods that a ship undergoes. These work requests could also be formatted directly from CSMP inputs. PMS schedules, changes and updates are also

prime candidates for microcomputer application.

Boiler records, RPM summary sheets and fuel consumption logs would not be candidates for automation as they are normally submitted on the same sheets on which the readings were taken.

3. Weapons Department

The Weapons Department could maintain an ammunition inventory that included the size, type and lot number of the ammunition on board, in addition to normal inventory control information. This would be invaluable when defective ammunition reports were received as it would provide a rapid means to determine whether or not the subject ammunition was on board the ship.

Ammunition expenditure reports and nuclear weapons messages could also be formatted by the ship's microcomputer system.

4. Supply Department

Supply personnel would benefit greatly from the system when having to order parts by message. This is as rigidly formatted as most of the Operations Department's message reports, and would be easily adapted to computer

assisted formatting. It would also be efficient to produce the weekly menus by encoding each meal on the disk by an alpha-numeric code.

The main use that the Supply Department could get out of the system would be inventory control of the ship's spare parts. This is one application that would be beneficial to have in a centralized file. It would require a data base of approximately four megabytes for a 20,000 line item inventory. This would include room for requisition status concerning each line item, enabling each department to determine that required parts were in stock or on order, with the shipping status of the order, if known, provided.

The ships operational targeting financial status (OPTAR) would also be an excellent application for a distributed system. This would allow each department to determine its OPTAR balance at any time, rather than having to wait for weekly reports from the Supply Officer.

Payroll information for the crew should not be automated at this time. If it were placed in a centralized data base, in conjuction with personnel records, the data would be susceptable to unauthorized disclosure or modification. If the payroll were automated, however, it should be done on a diskette, using a dedicated system, as classified material should be handled in Operations. The

diskettes would be stored in a safe, just as pay records are presently handled by disbursing personnel.

5. Ship's Administration Office

The ship's office has many potential applications for formated approach. The ship's diary (a daily report showing unauthorized absences, deletions from, and additions to the crew), the Plan of the Day (POD), Leave Authorization papers, enlisted evaluations and officer evaluations are all viable candidates for a dedicated mode of computerization. Many of these are OCR format, and on specific forms so a friction feed typewriter would be better utilized than a "tractor" feed printer, which requires special perforations along the edges of the forms. Daily correspondence, on the other hand, would best be printed on a line printer with a continuous feed capability, using fan folded forms, so there would be an ample continuous supply of paper, ~~thus~~ eliminating time required to feed the paper into the carraige.

It is not recommended that personnel records be automated at this time. In addition to the stringent training required to maintain personnel records in computerized format is the restriction that the Privacy Act imposes. Automation of personnel records would only be effective if the records were in a centralized data base

and, as stated earlier, todays medium and low cost computer systems are too susceptable to penetration to be used in this manner.

6. <u>Medical Department</u>

Automated medical diagnostic assistance would be extremely sophisticated for the hospital corpsman, that are stationed on small ships, to use. This is primarily designed for doctors, so it is not recommended for implementation. The medical records of the crew should not be entered into a common data base either, as unauthorized disclosure is to great a risk without an extensive protection feature present.

Some of the applications that were recommended are common to all departments on the ship and do not have security or privacy restrictions. These should be entered into a centralized data base and made available to all users. Damage Control PQS and Preventative Maintenance PQS are common to all shipboard ratings, so should be available for all stations to assist training the crew. The inventory of the ship's spare parts, and OPTAR, are also of interest to every department on board so should be in a common data base. Protection must be established to ensure the data is not altered inadvertantly.

Weekly PMS schedules should not be included in a common data base as the person performing the maintenance is required to sign the schedule to show that the particular job has been accomplished, which is a very fluid situation. update should be prepared on the Engineering Department's master PMS diskette to keep the schedule current.

No reports, or other data, that might be classified should be incorporated in a centralized data base, at this time, due to the previously mentioned security problems.

III. METHOD OF EVALUATION

The acquisition of a computing system not only involves detailed evaluation of tangible factors, but also of other factors that are not easily measured. Hardware performance factors, as speed and storage capability, are easily evaluated. Software reliability, on the other hand, is very difficult to determine, but no less important, when evaluating a system's suitability.

To demonstrate an evaluation and selection process for shipboard microcomputers, the equipment of over fifty manufacturers of microcomputers and peripheral hardware were evaluated in conjunction with this thesis. They are listed in Appendix A. Information was gathered about these units by attending computer oriented conventions, visiting manufacturers, talking to technical representatives on the telephone and requesting literature describing technical specifications of the equipment offered be fowarded by mail.

Most company representatives were extremely cooperative in providing the information required and many times included more information than was asked for on the questionaire. The questionaire, with sample answers is in Appendix B.

When assessing the merits of computing systems one key point must be borne in mind -- the system is being procured as a solution to a particular problem. Therefore there is much more to be considered than just internal speed before a final decision is reached on a particular system from a specific vendor. It would be unwise to purchase a fast "number crunching" machine when "text formatting" was going to be the primary function of the system, especially if the "number cruncher" was not capable of formatting text efficiently. With this in mind, the following aspects, listed in decreasing order with weights indicating relative importance in the next column, were studied thoroughly when determining what system would be best suited for the varied administrative functions found on Naval vessels:

1.	PHYSICAL REQUIREMENTS	(9)
2.	RELIABILITY	(6)
3.	EXPANDABILITY	(5)
4.	MAINTENANCE SUPPORT	(5)
5.	OPERATING SYSTEM	(5)
6.	PERIPHERAL HARDWARE	(5)
7.	FUNCTIONAL CAPABILITIES	(4)
8.	PROGRAM AVAILABILITY	(5)
9.	THROUGHPUT	(2)
10.	PRICE vs PERFORMANCE	(4)

This order of importance, and assigned weights, could vary depending on what was more important to the user. For shipboard use physical characteristics (size, regulated power, environmental factors, etc.) and reliability are extremely important; for shore establishments throughput might be the most important factor. When the systems were investigated, and compared, weights (maximum values are indicated in parenthesis) were assigned to each device. These weights were used in the final evaluation process by considering the computer system with the maximum number of points as being most desirable for use on board ship.

The reason that it may appear that an aspect has a greater weight than one listed as higher priority is because it has more elements. If two systems were to have equal final weight, or even close enough that they were in the final grouping, the final analysis would compare aspects of each system to determine where any differences occurred.

Appendix B also indicates the weighted values given to each element that was evaluated within the aspect and the total weight for the sample system. Each of these elements is discribed throughout the remainder of this chapter. The assignment of the weights is discussed in chapter four.

A. PHYSICAL REQUIREMENTS

Most U. S. Navy ships are extremely limited in available space for additional equipment. The most effective computer system in the world is worthless if it cannot be installed where it would be put to use. On many of the smaller, as well as older, ships the crew would be hard pressed to find room for a file cabinet, which is the size of many of today's computer systems. Therefore, the smaller the physical size of the equipment, the more adaptable it would be to shipboard use. Finding room to put the equipment on the ship is not the only size determining factor. Surface ships only have doors that are 26 inches wide and 60 inches high. That size opening is not too restrictive but many submarines have hatch openings that are 21 inches in diameter, and that size opening is restrictive.

Another major consideration is the electrical load that is required to operate the equipment. Most of the new systems only require five to twenty volt power supplies to operate the microprocessor. However, many of these power supplies are not regulated and ships are notorious for having power fluctuations, brownouts, and complete loss of electrical power. A necessary prerequisite was that the system had, at the least, a self-regulated power supply. If the system had the ship's power supply providing a continuous battery charge, with the system running off the battery, maximum points were given; fewer points were awarded if it had a battery back-up with automatic cut in as power failed; even

less provided the battery back-up was cut in manually; and minimum if it had no battery back-up at all. If the system did not have a regulated power supply that could withstand fluctuations of ten per cent it was not considered capable for shipboard use. This is based on the maximum fluctuations that most shipboard electronic equipment must be able to withstand without degredation.

Environmental conditions that the computer had to operate in were also considered under physical characteristics. It had to withstand temperature ranges of 32 to 100 degrees farenheit to remain in contention, and it had to be operable in an environment of relative humidity between 10 and 90 per cent. To be able to withstand these extremes, power supply cooling features had to be incorporated into the computer.

There is no reason to require that the microcomputer system be "militarized", with the possible exception of providing shock mounts for the units. Shock mounts would reduce the possibility of chips cracking or working loose, head crashes on the diskettes, etc when encountering rough seas. Any other design changes to militarize the equipment would add unnecessary costs to the equipment and counter the benefits derived from buying "off the shelf".

B. RELIABILITY

Reliability was examined in two phases. One phase was used to determine the Mean Time Between Failures (MTBF). A minimum MTBF of 3000 hours was required for a unit to remain in contention and recieve further evaluation. Considered in conjunction with the MTBF was the Mean Time To Repair (MTTR). A maximum of one hour was allowed for MTTR utilizing the manufacturers recommended spare parts allowance. It should not be contingent on any extra-ordinary technical training either.

The second phase was to attempt to determine company reliability. This is a very nebulous determination, at best. The criterea used was based on the manufacturer of the major components of the system (such as the microprocessor, mainframe and terminals), the size of the company, and how long the company had been in business. It would be poor judgement to propose a large purchase from a newly created company selling untried equipment as future support would be questionable.

Microprocessor performance was examined when weighing throughput of the systems. Peripheral system reliability was also determined seperately.

C. EXPANDABILITY

System expandability is a must for any microcomputer. A

minimum of 32 kilobytes of random access memory (RAM) was required for the microprocessor to be considered at all. It had to be expandable to a minimum of 64 kilobytes for serious consideration to be given for Navy use. This was based on projections of future applications requiring more memory in addition to the immediate applications described in the previous chapter.

The way that the "mother board" can have additional boards added to it is also important as it effects ease of maintenance. The two primary methods of attaching boards are to either have a plug-in board, or solder the board in place. The only advantage that a soldered-in-place expansion board has over the plug-in is that rough handling, such as heavy seas, would not jostle it out of place. That one advantage is very slight, however, as the slide-in boards are usually clipped securely in place. The plug-in boards have the distinct advantage of being easier to replace, remove, or add and also of eliminating the possibility of an errant soldering iron damaging other components in the main frame.

Expandability was not only relegated to memory. The ability of the computer to support peripheral devices is included when evaluating the complete system. The number of bits per second that are transferred (baud) must be able to be switched so the computer can be compatable with various terminals, printers and teletypes. The method of changing the

baud was considered, with the most efficient being accomplished by software. Next in efficiency was by utilizing a switching system, consisting either of toggles or wires that could be plugged into different positions on the board. The least efficient method was by having to move soldered connections.

The computer had to have the capability to support some form of a mass storage unit capable of holding 15 megabytes of data, a terminal and a printer to be considered for procurement. It had to have a serial and parallel port capability for support of both low and high speed peripheral hardware.

D. MAINTENANCE SUPPORT

Aligning itself closely with reliability of a system is the maintenance support it receives. A unit can have a MTBF of 10,000 hours, but if replacement parts are not available when a failure occurs the system would not effectively serve the user as designed.

Maintenance is simplified if the system has an effective diagnostic package. This can be accomplished by software programs, test points, front panel indications, diagnostic boards or a combination of the four. Diagnostics had to be accomplished without having to purchase expensive,

non-standard test equipment. The most common method of diagnosing equipment malfunctions seemed to be by utilizing the software approach, though some manufacturers did include some method of using diagnostic boards as well.

Most of the units that were investigated had a combination of plug-in chips and chips that were soldered in place. Many of the plug-in chips were those that would be replaced, removed or added if upgrading the system. Some of the less expensive and, according to technical representatives, more likely to fail were also of the plug-in variety. The expensive, highly reliable, chips are normally soldered on the boards.

Maintenance support should also include automatic notification of hardware updates as technological advances become available, especially if they improve performance. This notification should also include any software changes that may be necessary to effectively utilize the improvement. This update need not, nor is it expected to, be cost free but it should be made known to the user so that a decision can be made as to the desirability of procuring the change. This decision should be made by a central activity that has the overall responsibility of the microcomputer system. That activity should be the Naval Data Center (NAVDAC).

A training program for operator and maintenance personnel

would be extremely beneficial for an effective implementation of the microcomputer system. If this program cannot be provided by the vendor, one should be established by NAVDAC and taught at the Naval Regional Data Centers (NARDAC) on each coast.

E. OPERATING SYSTEM

An operating system is utilized to increase the effectiveness of computer resources. It is a collection of programs designed to manage the systems resources. The operating system performs functions such as selecting input and output devices, selecting and loading programs as required by the operator, controlling memory space allocation, and protecting data and priviledged instructions from being destroyed by operator error. It keeps track of the status of each resource, decides which process is to get the resource, allocates it and reclaims it when the process no longer requires it.

In order to evaluate the operating systems that were available for various microcomputers it was necessary to determine what the overhead cost of the operating system implementation was at the expense of the main storage capability, as well as its transportability. Transportability is extremely important to keep software costs to a managable figure. Therefore, an operating system that could be adapted

to different brands of hardware and support various types of software was looked at more favorably than a specialized operating system developed by a manufacturer for a specific computer. The more programming languages and input and output devices that the operating system could support, the more powerful it was and the more desirable it became. This was balanced against the amount of main memory required to be dedicated to the operating system.

It was also important to evaluate the efficiency of the operating system. An operating system might be able to support a distributed system or security, but if it took an extremely "long" time to accomplish this the end result would not be acceptable for the user. "Long" is nebulous, but for an interactive system a 30 second delay waiting for feedback seems long and one minute seems interminable. An inefficient operating system, coupled with equally poor programs, could well produce this length delay of execution.

Special features that the operatng system might have were also investigated. The method of starting or restarting the system, any type of file protection or security provisions, input and output buffering, and any form of memory retention cabability in the event of power loss were all taken into account when determining the feasability of the computer's operating system for use in a shipboard environment. The operating system had to provide an error recovery method so

that errors were annotated such that the operator could understand them, rather than having to refer to a publication to interpret some coded response.

Another major point considered during the evaluation was the ease of use of the operating system for the operator. This was balanced against the ease of programming high level languages and assembly language because many times programming is difficult when the operating system is simplified.

F. PERIPHERAL HARDWARE

Peripheral hardware that was considered for shipboard application included input and output (I/O) units that would interface with the microcomputer. I/O devices included paper tape units, cassette tape units eight inch and five inch diskette units, hard disk units, terminals and printers.

Consideration was given to the baud required to effectively utilize the device; to the access speed of the device; to the amount of overhead required of the operating system to support the device; and whether the device required serial or parallel ports for an effective interface with the computer.

1. Terminals

There were two types of terminals that were investigated for use on board ship. One type was the "smart" terminal, so called because it comes with a built in microprocessor. This allows many applications, such as text processing, to be done at the terminal without having to access the main computer. The output can then be transferred to a peripheral storage device. The rest of the time it is used as a standard terminal, which is as an interactive device between the computer and the user.

The second type of terminal investigated was the standard terminal, operating like a typewriter, to input desired information into the computer and transmit output information back to the operator.

Both of these come as a "hard copy" terminal, which includes a built in printer, or as a video display terminal, which displays the I/O on a cathode ray tube (CRT) much like a television screen.

Functions that were necessary for either type terminal to receive consideration as part of the computer system included the ability to send and receive upper and lower case letters and to have the full 128 American Standard Code for Information Interchange (ASCII) character set available.

When comparing the various hard copy terminals the same criterea that was applied to available printers was used; for the video display terminals it was necessary to determine the number of lines that were presented on the screen, the number of characters per line, whether it had a selectable baud, and whether it had half or full duplex (or both) capability. A minimum of 80 characters per line and 20 lines on the screen were required for a video display terminal or it was rejected from further consideration. A hard copy terminal was required to have a 132 character per line capability.

A comparison was also made between using a hard copy terminal and a video display terminal. This comparison included base cost, time advantage (or disadvantage), paper waste from using the hard copy terminal as an input device and potential savings from a reduced printer requirement. The video display terminal usually has the time advantage over the hard copy terminal, especially when editing. The text can be printed at the same speed for both, assuming identical baud and printer output.

2. Printers

There were many varieties of printer available to interface with the computer. Line, dot matrix, friction feed,

band, and daisy wheel printers were all examined for possible incorporation into the system. Teletypes (TTY) that could be used for radio communication were also included when looking at printers.

Functions that were investigated for each printer included printer line speed, print quality, number of characters per inch of the print (pitch), baud required and type ports required for interfacing.

3. Mass Storage Device

The last, and possibly most important, peripheral units that were investigated included various mass storage devices. These vastly increase the capability of the microcomputer by providing a virtual memory of up to several million bytes.

The various types of units, including paper tape, cassette, five inch and eight inch flexible diskettes ("floppy's"), and hard disk units were compared for memory capacity, access speed, error rate, and pilferability potential. The method of computer interface, required baud, power requirements and potential for information loss, due to unit failure caused by power fluctuations or rough seas, were also considered in determining the best type of mass storage device to include with the shipboard microcomputer system.

G. FUNCTIONAL CAPABILITIES

Although most of today's microcomputers have similiar functional characteristics there are some important differences that were examined.

In chapter two, it was determined that the system should have a centralized data base capability. This provision required that the system chosen had to be able to support a minimum of three users on line at any given time. It also had to have a form of write protection for the data base to prevent any inadvertent change of the data base.

Direct memory access (DMA), which allows a high speed device to communicate directly with on line memory was a desirable feature as well. This allows data to be accessed without involvement of the CPU, thus increasing throughput.

Input and output (I/O) interrupts and supervisor call interrupts were considered necessary functions for a business oriented computer. The I/O interrupts are utilized to control input and output operations and the supervisor call interrupt is necessary so the actual I/O can be performed.

For the administrative purposes that the shipboard microcomputer will fullfill, it was not deemed necessary to

have a hardware multiply or divide capability, or to have floating point arithmetic capability. These functions can be implemented in software, on eight bit machines, as shipboard applications don't require the power that 16 bit hardware capable units provide.

H. PROGRAM AVAILABILITY

Software has become extremely important in the overall equipment evaluation process. In fact, software has been the crucial factor in many hardware appraisals. Average hardware can have superior performance to excellent hardware if the former utilizes superior software.

Important considerations in evaluating potential software packages include:

1. Comparing the overhead of one high level language (HLL) with another.
2. Efficiency of one HLL with another
3. Power in terms of features
4. Ease of use
5. Diagnostic aids for debugging programs
6. Learning ease
7. Compatability with equipment and other software
8. Data base management capabilities

9. Availability of usable programs (these could include ones that would require slight modification to be used for specific purposes)

10. Program reliability

11. Transportability

12. If it is a HLL subset, how many features of the HLL were retained

The major considerations that determined software selection were program availability and portability.

I. THROUGHPUT

Throughput describes the amount of time that it takes the computer to process a given input and produce the desired output. Differences in hardware operation for most microcomputer systems are measured in milliseconds. Program operation, on the other hand, can vary significantly depending on whether the operating system interprets, or translates the input code. Interpreted code is usually a great deal slower than translated code.

The type processor used in the system, as well as the number of bits used for a word and the type bus used for interfacing are also instrumental in determining the effectiveness of the system throughput.

J. PRICE VS PERFORMANCE

There were four points assigned to evaluate price vs performance. After completing the earlier evaluations it was expected that only three to five systems would remain in contention. These would then be re-evaluated with the price of each compared to whatever differences there were in the system. The selection was to be based on what extra features would be considered advantagous and cost efficient for a shipboard system.

IV. PRESENTATION OF DATA

Many of the systems that were evaluated were immediately rejected for shipboard use. A thorough weighted evaluation was not conducted on these systems as they did not meet minimum criterea as described in chapter three. Other systems were rejected as they did not receive enough points to qualify for the final re-evaluation.

All systems, and their manufacturers, are listed in Appendix A, with their computed weights, or reasons why a detailed evaluation was not conducted.

An example of the distribution of points, while evaluating a microcomputer and its peripheral equipment, is shown using North Star's Horizon Microcomputer system, with its Winchester disk option. The Horizon was selected as an example as it was a good system, but had enough deficiencies to demonstrate how weights were applied to each of the aspects that were discussed in the previous chapter.

A sample questionaire, showing much of the data utilized in evaluating the Horizon Microcomputer system, is found in Appendix B.

A. PHYSICAL REQUIREMENTS

Horizon received only five points, out of a possible nine, because it does not have a battery back-up system available. The availability of a battery carried the most weight under physical characteristics (four points). Lack of a regulated power supply, or failure to meet environmental objectives, was cause for immediate rejection. Therefore, those two aspects did not have points assigned, but were used as a go/no-go criterea.

B. RELIABILITY

Four points were assigned to the system for its reliability. The microcomputer received the maximum two points for having an MTTR of 30 minutes, but only received one point for MTBF as it is only rated at the minimum requirement of 3000 hours.

One point was assigned to manufacturer reliability as North Star has been in business for only three years. A six year business record was used as the basis for assigning the maximum of two points. This was a subjective decision, based on the economic fluctions in the United States since 1973.

C. EXPANDABILITY

Horizon comes with optional RAM configurations of 16 kilobytes to 64 kilobytes. It has the capability to expand even further, using memory bank switching. The "mother board" has nine slots, in addition to the ones used for the microprocessor and 16K memory, to be used for expansion.

One point was lost for the baud being adjusted by switches, and rewiring, and not having a software capability to accomplish any baud change.

D. MAINTENANCE SUPPORT

North Star's system provides diagnostics by means of a software package. Further trouble shooting can be accomplished by means of a display board that can be plugged in behind the front panel.

Most chips are plugged into their respective boards for easy replacement, though a few are soldered in place, especially in the power supply.

North Star does not, as a rule, provide users with an automatic notification of new hardware developments, or of problems that users have encountered, nor do they have a user training program. If requested, as part of a contract, they will provide hardware development information

automatically. This resulted in a loss of only one-half point, as these are considered relatively minor faults in the overall schema due to the simplicity of the system.

E. OPERATING SYSTEM

No penalty was assigned to any system that did not have a security kernel, or other similiar method of providing data protection. If a system had been found that did have effective security protection, bonus points would have been awarded to that device. No microcomputer that was investigated was so rewarded.

Although the RAM board performs memory bank switching, which allows time sharing, there is no method presently available from North Star to implement a distributed system. This deficiency caused a one point deduction from the maximum weight, of five, that could be given to the operating system.

The Horizon comes equipped with a CP/M operating system which is, perhaps, the most transportable operating system in the micro computer industry.

F. PERIPHERAL SUPPORT

The microcomputer lost one point for peripheral support.

It comes equipped with Shugart drives for dual mini (5 1/2") double density diskettes. It also supports a Shugart dual Winchester disk drive capable of storing 45 megabytes. The double density mini-diskettes have approximately as much storage as the 8" floppies, in fact a little more, but they are not as reliable.

The terminal that comes with the basic system is a Soroq IQ-120 that is more than capable of fulfilling shipboard needs. Horizon also supports a variety of printers, including the Sprint-5, a daisy wheel printer, and the PR-80, a dot matrix printer. These were used in the cost vs performance aspect of the study for every system listed in Appendix A, if compatible, to provide a uniform basis of cost comparison.

G. FUNCTIONAL CAPABILITIES

The Z-80A processor board (ZPB) implements an eight-level vectored interrupt capability and an option for adding a wait state to all memory used in the computer. It does support DMA but not seperate memory lines, so only three of the possible four points were assigned to the system for this aspect.

H. PROGRAM AVAILABILITY

North Star does not support any form of COBOL or FORTRAN, at this time, therefore only three out of a possible five points were given. FORTRAN is not required for the shipboard implementation system, but COBOL is a necessity. Many programs presently used in the U. S. Navy could be adapted for the new systems if ANSI 74 COBOL, with some level 2 features, was available. Selecting Horizon would necessitate purchasing a COBOL compiler, or interpreter, from an outside source, or developing one at the centralized activity in charge of the shipboard information system support.

North Star BASIC does not provide the capability to implement a Data Base Management System, though the impression was given that one would be available in the near future. The company does provide an inventory control package, written in PASCAL, for small businesses, however.

Since UCSD PASCAL is available a working knowledge of PASCAL can be acquired. This is desirable, as PASCAL is the base upon which ADA is being developed for the Defense Department.

I. THROUGHPUT

The use of the Z-80A microprocessor provides twice the throughput in a given time than 8080 microprocessors can

produce. The Z-80A is not quite as powerful, or fast, as the MC-6809 but the differences would not be distinguishable to the user.

J. PRICE VS PERFORMANCE

The North Star Horizon is an excellent microcomputer for a single operator, or a very small business. With its present capabilities it is difficult to envision the requirement for a 45 megabyte storage capacity. A great deal of performance was achieved for the price ($23,158 for three systems, one Winchester disk, and peripherals), but many other systems had more to offer than the Horizon at a comparable price.

V. ALTERNATE SOLUTIONS TO THE PROBLEM

There are many potential solutions to the problem of automating information systems on U. S. Navy ships. These include, but are not limited to, whether to buy from a single vendor or multiple sources, whether to utilize dedicated or distributed systems, whether to partially or completely automate, etc. These questions, and others, are discussed with reasons, pro and con, given for each proposal.

A. DO NOT AUTOMATE

Not implementing an automated shipboard information system would maintain the status quo until the declining enlistment rate made its impact. All information would be handled as it is now handled. This method would not require any training in addition to that now recieved by ship's personnel, as no technological changes would be implemented. Another advantage, as a direct result of not automating, would be that no additional expenditure of funds would be required.

The alarming predictions of decreased enlistments, and present trends seem to bear these predictions out, could

result in a crash program to automate in the future. That type of approach historically results in unreliable equipment being purchased at an unreasonably high cost to solve a poorly defined requirement.

B. AUTOMATE WHEN SECURE SYSTEMS AVAILABLE

This proposal would delay implementation of the shipboard information system for a period of three to five years. This prediction is based on past development progress of new software to support hardware advances.

There are presently two microprocessors that have been recently developed to provide hardware support for two-state operations (Zilog's Z-8000 and Motorola's MC-68000). Two-state operations can be software implemented. This would, however, hinder performance and, when coupled with the speed degredation from implementation of the security kernel, throughput could be reduced to unacceptable levels. Research is presently being done to develop a kernel for the Z-8000 which will aid in implementation of a secure data base [7]. These proposals will not be completed until the end of 1979 and will not be ready for implementation until the end of 1980, at the earliest. Software development is progressing slowly for this equipment and, as the hardware has only been recently developed, there are still hardware problems to be resolved.

Training will also be a major factor in utilizing this solution as there would be no familiarization process, with more basic systems, before building up to full implementation with the more advanced system. Any delay in the secure system's development would further delay implementation.

This proposal would, however, provide the capability to include personnel records, health records, pay records, and secure documents in a centralized data base immediately upon implementation. It would also be a system that, assuming continuous available support, would be utilitarian for approximately 15 years.

C. UTILIZE SNAP II

The SNAP II proposal requires a 60 megabyte mass storage capability, stringent security capabilities and an eight year implemention schedule. It is not presently viable for a micro computer system due to the security requirements, but it is a viable alternative utilizing a minicomputer system. SNAP II provides for extensive training of shipboard personnel to use the system and uses a centralized software design concept.

This system would require a PDP-11/50 with the Secure

Unix Operating System. This equates to a cost of approximately \$300,000 to \$500,000 per ship. It is predicated on equipment that is already eight years old and, with an eight year implementation plan and an additional eight year replacement plan, expects sixteen years of manufacturer's support. Based on the rapid development of more powerful microcomputers and resulting price reductions, it is difficult to envision support of the PDP-11/50 in 1996.

USS Gridley data has indicated there has been difficulty in maintaining hard disks in an "at sea" environment for their minicomputer. This would slow down the proposed access speed of the proposed 60 megabyte mass storage capability as tape would have to be used as the storage medium.

D. DEDICATED SYSTEMS

The purchase of microcomputers that only performed dedicated tasks would provide a cost advantage over distributed systems. Security would be a minimal problem as the diskettes, tapes, or other output, could be locked in safes as secure documents are now handled. It would also open the field to more computers that are presently on the market and less expensive than systems that are capable of supporting multiple users and a centralized data base. It would also simplify user training because the systems would

not be as complicated. These systems could then be replaced by the multi-state systems, like the Z-8000, with secure operating systems, when they were tested and software support was available.

This proposal would severely limit shipboard applications that could presently be implemented. It would also represent a quantum increase in system difficulty for the user when the new system was acquired. That would require an intensive training program to ensure operator, and technician, familiarity with the new system.

Shipboard training programs, such as Damage Control PQS, would have to be accomplished at a departmental level, requiring diskette redundancy, and supply inventory and OPTAR information would have to be distributed manually.

E. DISTRIBUTED SYSTEMS

Utilizing a distributed system would result in a micro computer that was capable of supporting a centralized data base. This would be restricted to using non-secure data in the data base. Dedicated operations could be utilized for performing local departmental information and for information that would normally require a secure data base. Training would not be as difficult as that required for SNAP II, but more difficult than that required for dedicated

systems. It also would not need as intensive a training program when upgrading to secure systems, when they become viable alternatives.

This proposal would still necessitate processing some documents manually and require redundant data bases with the resulting problems of maintaining the data accurately in each file. If secure systems became available sooner than predicted, the old systems would be targets for replacement before it would be cost effective to do so.

F. PURCHASE OPTIONS

One advantage of purchasing microcomputer systems from a single vendor is the guarantee of compatible systems. A large purchase should also result in a lower cost per unit in addition to adaquate hardware and software support.

Disadvantages include the possibility of losing all support if the vendor goes out of business. This is a very real consideration as the small computer business is very volitile at the present time. Training support, and on site technical support also becomes more difficult when a vendor is located in California and the ship or station requiring assistance is in Florida.

The disadvantages in a single vendor purchase scheme

become advantagous when applied to a multiple vendor purchase scheme, and vice versa. Therefore, if East and West coast vendors were selected and on board technical support would be improved, the failure of a single vendor would not be disasterous but unit cost could be higher and great care would have to be taken to ensure hardware and software compatability.

VI. CONCLUSION

This thesis proposed a method to evaluate a standardized microcomputer system that could be installed on small U. S. Navy ships. These computers would be for non-tactical use only. The principle benefit of the program would be to standardize systems so that software, and hardware, would be transportable from ship to ship. Such standardization should result in reduced acquisition costs, operator training requirements, and maintenance training requirements thus providing improved reliability and maximum use of the microcomputer system's capabilities.

All software review, purchase and modifications should be accomplished by a centralized activity, preferably NAVDAC. To maintain standardization and reliability of the software provided by NAVDAC, ship's personnel should not be authorized to program or effect software changes of any kind.

The system should be procured from a single source with the requirement that full maintenance and operator training support be supplied for the first year, or until it is incorporated into the Navy training program. Technical, hardware and software support should be supplied for the

life of the system, if economically feasible. This sole source procurement should ensure compatability between ships, simplify future system expandability and provide a cost benefit through a large purchase discount.

The evaluation procedure employed narrowed the field of fifty manufacturers down to four that were considered satisfactory, based on the criterea established for a shipboard information system. These systems are compared in Appendices C and D. The four companies, and their systems were:

1. Altos Computer	ACS8000-6
2. Cromemco	CS-3
3. Ohio Scientific	Challenger III
4. Southwest Technical	SWT 6809

The Challenger III system was selected because of its 29 megabyte Winchester technology hard disk capability coupled with dual eight inch "floppy" disks; utilization of Z-80, 6800, and 6502A microprocessors; extensive software packages; and a built in provision for acceptance of the newly developed 16 bit microprocessors, such as the Z-8000. This is accomplished by using a 16 bit data bus, 20 address bits and processor select codes that are reserved for future use. The price for the system, as described below, is $26,848.

The Challenger III C3-C and C3-S1 can be procured with 64 kilobyte RAM, though standard configuration is with a 48K and a 32K RAM respectively. It comes equipped with a multi-user operating system, or a time share capability, and has Fortran, Basic and Cobol presently implemented under a CP/M operating system. Pascal is due to be available in early 1980. Available software includes an Information Management system with an "English" query language for information retrieval and a Text Formatting system. Many other business oriented programs are available, including inventory control and personnel files. The latter, as stated earlier, should not be implemented until the Z-8000, or equivalent system, is procured.

One Challenger III C3-C and two C3-S1's should be procured for each destroyer sized ship and smaller. Cruisers should have, in addition to the Challenger III C3-C, a C3-S1 for each department. This will provide a centralized data base capability for the ship and also provide the capability to handle classified material in a dedicated mode.

The C3-C should be located in Supply, with Engineering personnel having access to it. Centralized files for inventory control, and the master PMS schedule should be implemented and stored on the 29 megabyte winchester disk supplied with this system. Damage Control PQS and PMS PQS

training programs should also be stored on the winchester disk. The PMS schedule and training programs could be implemented at once, whereas the inventory control data base might be difficult to implement while the ship was operating. An opportune time to install the inventory control package might be while the ship was in an overhaul, or stand down, status. A printer should also be located in Supply. The system should have an output port connected to the correspondence quality printer located in the ship's administration office.

One of the C3-S1 systems, which is equipped with dual eight inch "floppy" diskettes, should be located in a space for use of Weapons Department and Operations Department personnel. It will mainly be used in a dedicated mode, but should have access to the data bases and training programs located in the C3-C. This system should have a multiplexer I/O channel to a TTY in Radio Central, if it can be accomplished without violating electronic emissions standards. The system should be equipped with a dot matrix printer and also be able to utilize the printer located in the Ship's Office.

The other C3-S1 system should be located in the ships Administrative Department's office. It should also have access to the C3-C for utilization of the data bases and training programs. A daisy wheel impact printer with a

friction feed capability should be installed so it can be used for the many OCR formatted reports that are required of a ship, as well as for formal correspondence.

System testing and acceptance should follow the format proposed by SNAP II in that twelve systems should be procured, and installed, for shipboard testing. Special attention should be given to the winchester disk to ensure its reliability in an "at sea" environment and that it does not have the hard disk problems encountered by the USS Gridley system. The evaluation phase should last a minimum of three months.

If the evaluation is successful, a maximum of two years should be utilized to equip the ships designated to receive the microcomputer systems. Planning should commence immediately to prepare for system expansion to meet the SNAP II proposals. That would help maintain the state of the art for as soon as hardware and software that met SNAP II design requirements became available and, more importantly, reliable a procurement and implementation plan would be ready. This proposal should be designed so upgrading would be compatable with the Challenger III systems thus reducing cost, time and training required for implementation.

APPENDIX A

SYSTEMS INVESTIGATED

MANUFACTURER	SYSTEM	WEIGHT
Alpha Micro Systems	AM-100	35
Altos Computer Systems	ACS8000-6	45 1/2
Apple Computer	APPLE II	hobby
Applied Computer Systems	SMART ALEC	37
Applied Data Communications, Inc	EVENT 1000	37
Applied Digital Data Systems, Inc	SYSTEM 75	32
Atari	ATARI 800	hobby
Bee Hive International	MICRO BEE 2	31
Commodore	PET 2001	hobby
Compucorp	MARK II	22
Computer Covenant Corp	CPBS-1	38
Computer Data Systems	ACCOUNTANT	limited
Cromemco	SYSTEM III	46 1/2
Data General	CS/20	41
Data Terminals and Communications	TASKMASTER	44 1/2
Digital Equipment Corp	DATA SYSTEMS 320	45
Digital Group	SYSTEM 4	43.5
Digital Micro Systems	DSC-80	28

Dyna Byte	DB-8/1	no info
Findex Corp	FINDEX 128	no info
GRI Computer Corp	GRIP	32
Imsai	VDP 80/1050	45
Industrial Micro Systems, Inc	SERIES 8000	limited
Jade Computer Systems	PIGGY	hobby
MicroDaSys	MDS SYSTEM 3	36 1/2
Midwest ScientifiC Instrument, Inc	MSI SYSTEM 76	33
North Star Computers	HORIZON 2	36 1/2
Northwest Micro Computers	NMS 85/p	39
Ohio Scientific	CHALLENGER III	46 1/2
PCE Systems	SPHINX	22
Pertec Computer Corp	PCC 2000 MITS 300	37 36
Polymorphic Systems, Inc	SYSTEM 8810	30
Processor Technology	SOL SYSTEM IV	34
Qantel	SYSTEM 210	31
Q 1 Corp	Q1/microlite	25
Radio Shack	TRS-80	hobby
Research Machines Ltd	380Z	hobby
Scientific Data Systems	SDS-100 SDS-420	33 1/2 35 1/2
Smoke Signal Broadcasting	CHIEFTAN III	37
Southwest TechnicalSWT-6809 Products	46 1/2	
Sperry Univac Corp	BC/7	36
STM Systems	BABY 1	28

Technical Design Labs	XITAN	34 1/2
Tektronix	MODEL 4051	30
Texas Instruments	S3P 990/4	36 1/2
Thinker Toys	DISCUS/2D	reg vlt
Vector Graphics	SYSTEM B	29
Wang	WANG 2200	39 1/2
Western Digital	PASCAL MICRO ENGINE	limited

APPENDIX B

HORIZON 2 ANALYSIS

MANUFACTURER		NORTH STAR			
PHYSICAL	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
size	2	16 x 7 x 17	2		
reg pwr sply	1	10 %	1		
forced cool	2	yes	2		
batt back-up	4	no	0		
temp rnge	-	32 - 100 F	-		
humid rnge	-	10 - 90 %	-		
TOTAL PTS	9		5		
RELIABILITY	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
MTBF	2	3000 hr	1		
MTTR	2	30 min	2		
yr company established	2	1976	1		
TOTAL PTS	6		4		
EXPANDABILITY	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
max RAM	1	>64k	1		
mother board allow expans	1	yes	1		
how	1	slotted	1		
switch baud	1	yes	1/2		
how	1	switch/plugs	1/2		

TOTAL POINTS	5		4		

MAINTENANCE	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
H/W diagnostics	2	yes	2		
how	1	panel & S/W	1		
chips plug in or solder on	1	plug in	1		
auto notify H/W updates	1/2	will	1/2		
training pkg	1/2	no	0		
TOTAL POINTS	5		4.5		

OPERATING SYSTEM	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
multi-user	1	yes	1		
timeshare	1	yes	1		
distributed	1	no	0		
auto boot	1	yes	1		
security	+5	no	0		
error recovery	1	some	1		
TOTAL PTS	5+5		4+0		

PERIPHERALS	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
winchester size	1	yes 45 M	1		
floppy size sides/density	1	5 1/2" single/double	0		
type I/O port	1	S,P,RS-232	1		
terminals ASCII upper/lower char/line # video lines	1	Soroq IQ-120 128 yes 80 24	1		
printers type	1	Sprint 5 PR 80 dsy whl dot mtx	1		

speed		45 cps	45 cps		
pitch		10,12,15	10		
print		impct	impct		
TOTAL PTS	5		4		

FUNCTIONAL	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
DMA	1	yes	1		
vect interrupts	1	yes	1		
memory bank switching	1	yes	1		
seperate memory disable lines	1	no	0		
TOTAL PTS	4		3		

PROGRAM AVAIL	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
High Level Language support	4	Basic UCSD Pascal	3		
DBMS	1	no	0		
TOTAL PTS	5		3		

THROUGHPUT	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
processor	1	Z-80	1		
HLL translate or interpreted	1	both	1		
TOTAL PTS	2		2		

COST ANALYSIS	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
		3 units: 12360 1 W disk: 6000 1 Sprint: 2900 2 PR-80: 1898			
total cost		$23158			
TOTAL PTS	4		3		
SYSTEM TOTAL	50		36.5		

APPENDIX C

CHALLENGER III and SWT-6809 ANALYSIS

MANUFACTURER		OHIO SCIENTIFIC		S/W TECH PROD	
SYSTEM		CHALLENGER III		SWT-6809	
PHYSICAL	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
size	2	24 x 12 x 21	0	17 x 6 x 18	1
reg pwr sply	1	10 %	1	10 %	1
forced cool	2	yes	2	yes	2
batt back-up	4	yes	4	yes	4
temp rnge	-	32 -105 F	-	32 - 105 F	-
humid rnge	-	10 - 90 %	-	10 - 90 %	-
TOTAL PTS	9		8		9
RELIABILITY	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
MTBF	2	3500	2	3000	1
MTTR	2	30 min	2	30 min	2
yr company established	2	1975	1	1975	1
TOTAL PTS	6		5		4
EXPANDABILITY	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
max RAM	1	>64k	1	>64k	1
mother board expandable	1	yes	1	yes	1
how	1	slotted	1	slotted	1
switch baud	1	yes	1	yes	1

how	1	S/W	1	S/W	1
TOTAL POINTS	5		5		5

MAINTENANCE	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
H/W diagnostics	2	yes	2	yes	2
how	1	S/W	1	S/W	1
chips plug in or solder on	1	both	1	both	1
auto notify H/W updates	1/2	yes	1/2	yes	1/2
training pkg	1/2	yes	1/2	yes	1/2
TOTAL POINTS	5		5		4.5

OPERATING SYSTEM	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
multi-user	1	yes	1	yes	1
timeshare	1	yes	1	yes	1
distributed	1	yes	1	yes	1
auto boot	1	yes	1	yes	1
security	+5	no	Ø	no	Ø
error recovery	1	yes	1	yes	1
TOTAL PTS	5+5		5+Ø		5+Ø

PERIPHERALS	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
winchester size	1	yes 29M	1	yes 16M	1
floppy size sides/density	1	8" single/single	1	8" single/single	1
type I/O port	1	S,P,RS-232	1	S,P,RS-232	1
terminals ASCII upper/lower char/line # video lines	1	Soroq-12Ø 128 yes 8Ø 24	1	Soroq-12Ø 128 yes 8Ø 24	1

type		dsy whl dot mtx		dsy whl dot mtx	
speed		45 cps 45 cps		45 cps 45 cps	
pitch		10,12,15 10		10,12,15 10	
print		impct impct		impct impct	
TOTAL PTS	5		5		5
FUNCTIONAL	**pts**	**SYSTEM DATA**	**wt**	**SYSTEM DATA**	**wt**
DMA	1	yes	1	yes	1
vect interrupts	1	yes	1	yes	1
memory bank switching	1	yes	1	yes	1
seperate memory disable lines	1	yes	1	yes	1
TOTAL PTS	4		4		4
PROGRAM AVAIL	**pts**	**SYSTEM DATA**	**wt**	**SYSTEM DATA**	**wt**
High Level Language support	4	Basic Cobol Fortran	4	Basic Cobol	4
DBMS	1	yes	1	yes	1
TOTAL PTS	5		4		4
THROUGHPUT	**pts**	**SYSTEM DATA**	**wt**	**SYSTEM DATA**	**wt**
processor	1	Z-80	1	MC-6809	1
HLL translate or interpreted	1	both	1	both	1
TOTAL PTS	2		2		2
COST ANALYSIS	**pts**	**SYSTEM DATA**	**wt**	**SYSTEM DATA**	**wt**
total cost		3 units:21050 Sprint-5: 2900 2 PR-80: 1898 $26848		3 units:23230 Sprint-5: 2900 2 PR-80: 1898 $29028	
TOTAL PTS	4		4		4
SYSTEM TOTAL	50		47		46.5

APPENDIX D

ACS8000-6 and CS 3 ANALYSIS

MANUFACTURER		ALTOS COMP SYST		CROMEMCO	
SYSTEM		ACS8000-6		CS 3	
PHYSICAL	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
size	2	16 x 7 x 17	2	20 x 12 x 19	2
reg pwr sply	1	10 %	1	10 %	1
forced cool	2	yes	2	yes	2
batt back-up	4	yes	4	yes	4
temp rnge	-	32 -105 F	-	32 - 105 F	-
humid rnge	-	10 - 90 %	-	10 - 90 %	-
TOTAL PTS	9		9		9
RELIABILITY	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
MTBF	2	3000	1	3500	2
MTTR	2	30 min	2	30 min	2
yr company established	2	1975	1	1975	1
TOTAL PTS	6		4		5
EXPANDABILITY	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
max RAM	1	>64k	1	>64k	1
mother board expandable	1	yes	1	yes	1
how	1	plug in chips	1	slotted	1
switch baud	1	yes	1	yes	1

how	1	S/W	1	S/W	1
TOTAL POINTS	5		5		5
MAINTENANCE	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
H/W diagnostics	2	yes	2	yes	2
how	1	S/W	1	S/W	1
chips plug in or solder on	1	both	1	both	1
auto notify H/W updates	1/2	yes	1/2	no	Ø
training pkg	1/2	no	Ø	no	Ø
TOTAL POINTS	5		4.5		4
OPERATING SYSTEM	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
multi-user	1	yes	1	yes	1
timeshare	1	yes	1	yes	1
distributed	1	yes	1	yes	1
auto boot	1	no	Ø	yes	1
security	+5	no	Ø	no	Ø
error recovery	1	yes	1	yes	1
TOTAL PTS	5+5		4+Ø		5+Ø
PERIPHERALS	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
winchester	1	yes	1	yes	1
size		15M		16M	
floppy size	1	8	1	8"	1
sides/density		double/single		single/single	
type I/O port	1	S,P,RS/232	1	S,P	1/2
terminals	1	Soroq-12Ø	1	Crom-31Ø1	1
ASCII		128		128	
upper/lower		yes		yes	
char/line		8Ø		8Ø	
# video lines		24		24	

printers	1	Sprint 5	PR 80	1	C-3355	C-3779 1
type		dsy whl	dot mtx		dsy whl	dot mtx
speed		45 cps	45 cps		45 cps	45 cps
pitch		10,12,15	10		10,12,15	10
print		impct	impct		impct	impct
TOTAL PTS	5			5		4.5

FUNCTIONAL	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
DMA	1	yes	1	yes	1
vect interrupts	1	yes	1	yes	1
memory bank switching	1	yes	1	yes	1
seperate memory disable lines	1	yes	1	yes	1
TOTAL PTS	4		4		4

PROGRAM AVAIL	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
High Level Language support	4	Basic Cobol Fortran UCSD Pascal	4	Basic Cobol Fortran UCSD Pascal	4
DBMS	1	yes	1	yes	1
TOTAL PTS	5		5		5

THROUGHPUT	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
processor	1	Z-80	1	Z-80	1
HLL translate or interpreted	1	both	1	both	1
TOTAL PTS	2		2		2

COST ANALYSIS	pts	SYSTEM DATA	wt	SYSTEM DATA	wt
total cost		3 units:20230 Sprint-5: 2900 2 PR-80: 1898 $25028		3 units:24550 C-3355: 3995 2 C-3779: 2990 $31435	
TOTAL PTS	4		3		3
SYSTEM TOTAL	50		45.5		46.5

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